INTERNATIONAL STANDARD

ISO14624-1A
DRAFT
E. Davis

Space systems — Safety and compatibility of materials —

Part 1:
Determination of upward flammability of materials

Systèmes spatiaux — Sécurité et compatibilité des matériaux —

Partie 1: Détermination de l'inflammabilité verticale des matériaux

Proposed revision to ISO14624-1

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14624-1 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

ISO 14624 consists of the following parts, under the general title *Space systems — Safety and compatibility of materials*:

— *Part 1: Determination of upward flammability of materials*

— *Part 2: Determination of flammability of electrical-wire insulation and accessory materials*

— *Part 3: Determination of offgassed products from materials and assembled articles*

— *Part 4: Determination of upward flammability of materials in pressurized gaseous oxygen or oxygen-enriched environments*

— *Part 5: Determination of reactivity of materials with aerospace propellants*

— *Part 6: Determination of reactivity of processing materials with aerospace fluids*

— *Part 7: Determination of permeability of materials to aerospace fluids*

Introduction

Throughout this part of ISO 14624, the minimum essential criteria are identified by the use of the imperative or the key word “shall”. Recommended criteria are identified by the use of the key word “should” and, while not mandatory, are considered to be of primary importance in providing serviceable, economical and practical designs. Deviations from the recommended criteria may be made only after careful consideration, extensive testing and thorough service evaluation have shown an alternative method to be satisfactory.

Space systems — Safety and compatibility of materials —

Part 1:
Determination of upward flammability of materials

1 Scope

This part of ISO 14624 specifies a method for the determination of the flammability of aerospace materials by upward flame propagation. Specifically, this test determines if a material, when exposed to a standard ignition source, will self-extinguish and not transfer burning debris to adjacent materials which can be ignited by such debris.

2 Conformance

The test shall be performed in an accredited test facility (see Annex A for guidelines).

The authority having jurisdiction, or the test requester, shall provide properly identified material(s) for testing. Alternatively, accredited test facilities may be authorized by the test requester to procure the appropriate material(s).

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

consumption as determined by visual observation, post-test examination, video of burn, and/or other means.

3.1
burn length
distance from the bottom of the specimen to the farthest evidence of damage to the test specimen due to flame ~~impingement~~

NOTE This distance includes areas of partial or complete combustion, charring or embrittlement, but does not include areas which are sooted, stained, warped or discoloured, or areas where the material has shrunk or melted away from the heat.

3.2
burn propagation time
time that elapses from ignition of the specimen until vertical flame propagation stops

3.3
self-extinguishing
phenomenon wherein the burn length of a material does not exceed 150 mm

Specimen
one standard-sized section of a material used for testing. Five specimens are needed for one standard test.

3.4
thin-film specimen
specimen with a total thickness of less than 0,25 mm

NOTE Fabrics or coatings applied to a substrate are excluded.

3.5
transfer of burning debris
movement of burning particles from a burning specimen to adjacent materials

ambient conditions
conditions with an oxygen concentration of 20.9 percent, a pressure of 101.4 kPa, and a temperature of 23 (+- 5) degrees C.

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3.6
worst-case configuration
combination of material thickness, test pressure, oxygen concentration and temperature that make the material most flammable

3.7
worst-case use thickness
material thickness that, for a specific application, makes the material most flammable

EXAMPLE The smallest thickness for use without a substrate or the greatest thickness for use with a substrate.

3.8 Maximum Allowable Oxygen Concentration: The Maximum oxygen concentration at which at least five specimens pass the acceptance criteria of this test.

4 Principle

An ignition source with specific characteristics is applied for a defined period of time to the lower end of a specimen of material oriented vertically in a test chamber or fume hood containing a specific test environment. The maximum post-test burn length for at least three standard-sized specimens is recorded. Materials are considered self-extinguishing, when this test method is used, if the maximum burn length for three standard-sized specimens does not exceed 150 mm. In addition, the ignited specimens shall not transfer burning debris to adjacent materials. Failure of any one specimen constitutes failure of the material in that test environment. Materials shall be tested in the worst-case configuration.

In addition, the ignited specimens shall not ignite the paper (produce flaming combustion) below the test specimens, which would indicate that the transfer of burning debris would have sufficient energy to ignite adjacent materials. If, during a test, the paper used as an indication of the transfer of burning debris ignites because of burning debris, subsequent burns during the same material test shall be conducted without paper. Note: This is done because the burning paper can inhibit the burning of the test specimen.

5 Reagents

5.1 Test gases, premixed before exposing the specimen to them and verified for conformity with the specification (including accuracy) for oxygen concentration to within $^{+1}_{0}$ %.

Materials shall be tested in the worst-case configuration. If the worst-case environment is uncertain, determination of the maximum oxygen concentration is recommended.

6 Test system

6.1 Test chamber, large enough so that complete combustion of the specimen can occur with no more than a 5 % relative depletion of oxygen concentration. In addition, the test chamber shall not interfere chemically or physically with the test.

~~Testing may be conducted in a fume hood if the above conditions can be met.~~

Testing may be conducted in a fume hood in air if the above conditions are met and the test results are verified against test chamber testing results. Air shall not be allowed to flow during tests.

6.2 Measuring devices, properly calibrated.

6.3 Chemical ignition source, meeting the following specifications under ambient conditions:

a) energy: 3 000 J;

b) temperature: 1 100 °C ± 90 °C;

c) burning duration: 25 s ± 5 s;

d) maximum visible flame height: 65 mm ± 6,5 mm.

The test atmosphere shall consist of a mixture of oxygen and nitrogen, with the oxygen level being the highest that the material could witness in use conditions.
The test gases shall be mixed thoroughly before testing a specimen.
The gases may be premixed before introduction of the gases into the test chamber or mixed inside the test chamber.
When gases are mixed in the chamber, they shall be circulated with a fan until a homogeneous mixture is attained, as determined by a gas analyzer.

Annex B provides a procedure for preparing, certifying and storing chemical ignitors.

Alternative ignition mechanisms may be utilized if they meet the requirements outlined in a) to d) above.

6.4 Power supply, capable of providing 15 A (RMS), connected to a bare 20 AWG nickel-chromium wire (6.5) to initiate the igniter.

6.5 Bare 20 AWG nickel-chromium wire, with a nominal resistivity of 2,3 Ω·m and of sufficient length to wrap three equally spaced turns around the chemical igniter.

6.6 Suitable specimen holder, capable of supporting the specimen in the vertical position.

6.6.1 Standard specimen holder (see Figure 1), allowing 50 mm of the width of the specimen to be exposed and extending over the full length of the specimen.

The bottom of the specimen holder shall be located at least 250 mm from the bottom of the test chamber.

6.6.2 Specimen holder for thin-film specimens, allowing at least 50 mm of the width of the specimen to be exposed and minimizing shrinkage of the test material away from the flame. For large thin-film specimens, the exposed width may be up to 150 mm.

Two types of specimen holder may be used:

a) a holder similar to the standard specimen holder (see 6.6.1 and Figure 1), except that it employs three wing-nut clamps instead of one long clamp;

b) a holder employing needle rakes to hold the specimen (see Figure 2).

6.7 Scale, attached to one side of the specimen holder, for measurement of the burn length.

6.8 Sheet of paper, mounted horizontally approximately 200 mm below the specimen holder, but 50 mm above the bottom of the test chamber, centred directly below the specimen and having the following characteristics:

a) dimensions: (200 mm ± 50 mm) × (300 mm ± 50 mm);

b) surface density: between 200 g/m^2 and 300 g/m^2;

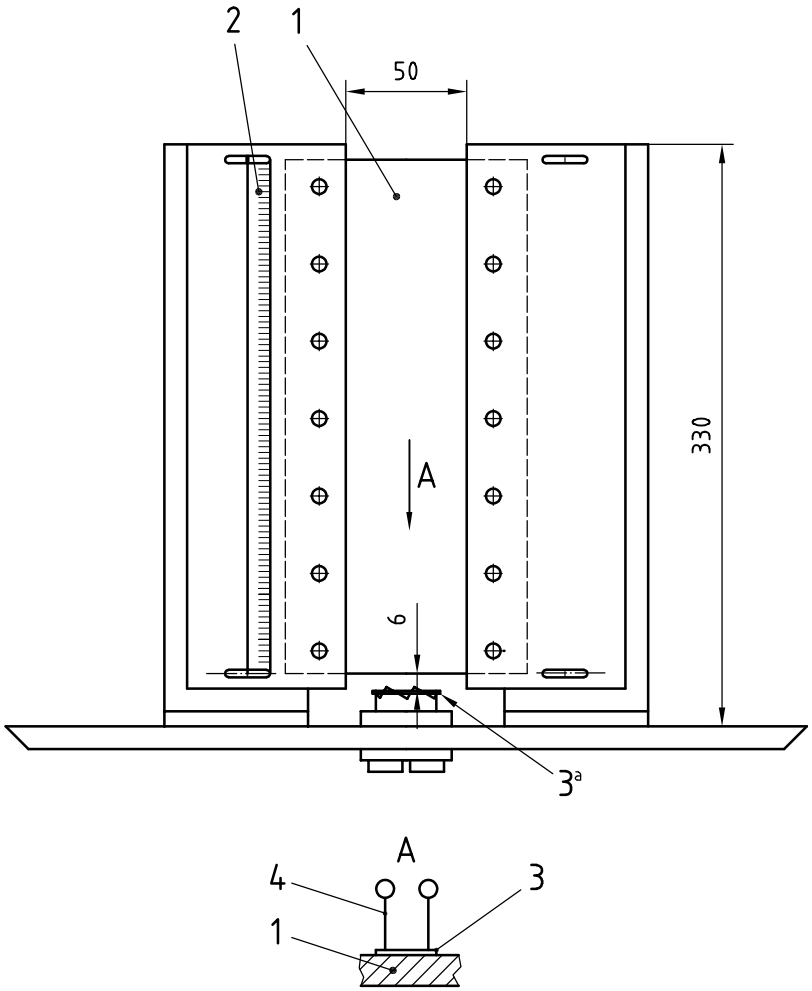
c) type: chemical wood index;

d) colour: uniformly white;

e) condition: clean, free from dirt spots, oil spots and foreign matter (lint, fuzz, etc.), free from holes, tears, cuts, folds and scuff marks, and containing no splices.

The sheet of paper is used to assess if burning debris from the specimen would cause ignition of adjacent materials.

Dimensions in millimetres



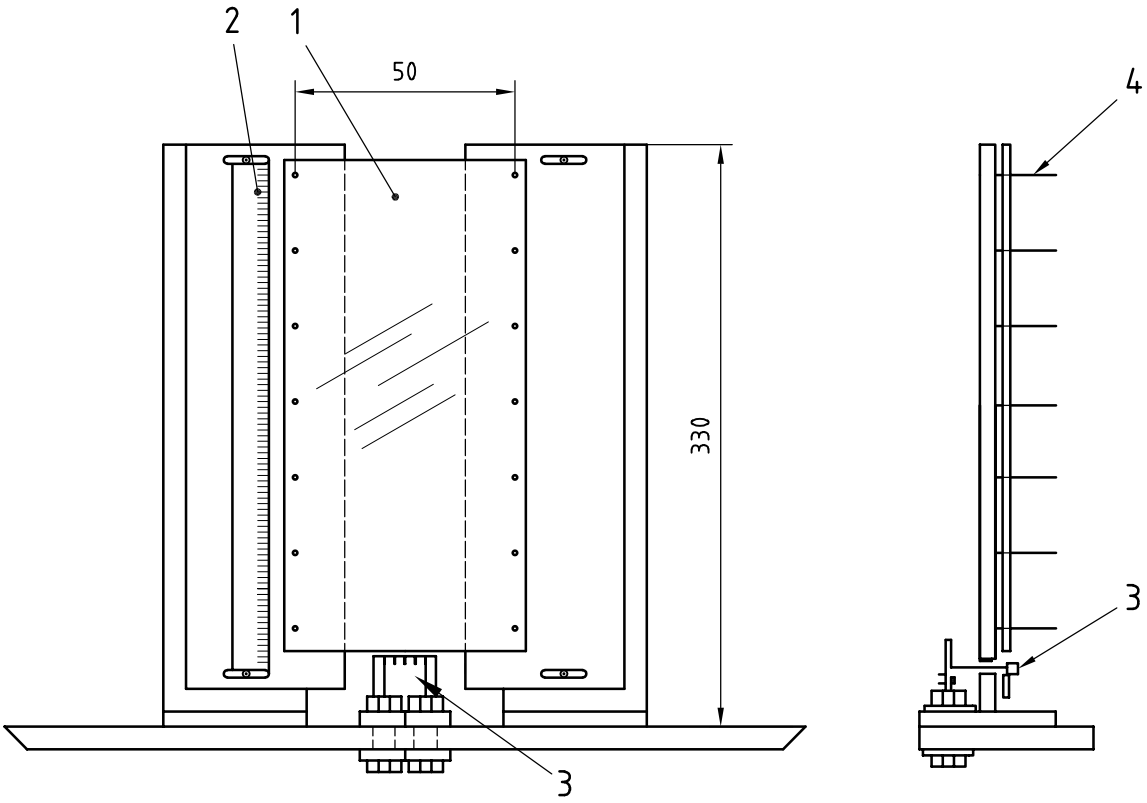
Key

1 specimen
2 scale
3 ignitor
4 nickel-chrome wire

[a] The ignitor is placed inside the coil.

Figure 1 — Standard specimen holder

Dimensions in millimetres



Key

1 specimen
2 scale
3 ignitor
4 needle

Figure 2 — Needle-rake mount for thin-film specimens

7 Test specimens

7.1 Materials

The minimum quantities of materials required to perform each test properly are summarized in Table 1. Actual test configurations and material quantities for material forms other than those listed (e.g. O-rings and other seals) shall be established and approved by the responsible procuring activity/user materials organization.

Table 1 — Minimum quantities of materials required for testing for each atmosphere

Form of material	Minimum quantity
Sheets	6 specimens measuring 300 mm × 65 mm × the required thickness
Thin films	6 specimens measuring 300 mm × 75 mm × the required thickness When the influence of the test stand on the results is of concern, large thin films measuring 300 mm × 200 mm × the required thickness may optionally be used, subject to the approval of the authority having jurisdiction.
Coatings	Sufficient to cover, at the required thickness, 6 substrates measuring 300 mm × 65 mm
Foams	6 specimens measuring 300 mm × 65 mm × the required thickness
Insulated wires	2 m in length

As a minimum, all materials used in testing shall meet or exceed user specifications.

Material and configured-system characteristics can be significantly compromised by sources of contamination, such as exposure to solvents, cleaning agents, abnormal temperatures, variations in humidity, environmental pollutants, particulates and handling. It is important that exposure of test material(s) to these and other contamination sources be sufficiently controlled to minimize variation in test results.

7.2 Reception and inspection of material

7.2.1 Receive and visually inspect the test material: when received, it shall be accompanied by proper identification and its thickness shall correspond to the specified worst-case use thickness. Any flaws shall be noted. Specimens should have been cleaned and dried to the end-use specifications prior to receipt at the test facility.

7.2.2 If required, prepare specimens to the proper dimensions, including worst-case use thickness.

7.2.3 If specimens are received with obvious contamination, clean them. All cleaning methods shall be approved by the test requester prior to use. Surface contamination should be removed by washing with deionized water and mild detergent, rinsing with deionized water, and drying with filtered nitrogen gas. As a minimum, particulates on the surfaces of solid porous specimens should be removed with filtered nitrogen gas.

7.2.4 After preparation and/or cleaning at the test facility, inspect the specimens to ensure that they are at the specified worst-case use thickness. Any flaws and any residual contamination shall be noted. If the flaws result from specimen preparation at the test facility, new specimens shall be prepared. Specimens shall be weighed and individually identified.

7.3 Preparation of test specimens

7.3.1 Sheet and other bulk-form specimens shall be cut to 300 mm × 65 mm in the worst-case use thickness. Materials, configurations and components that cannot be prepared to these requirements shall be tested in the configuration as purchased. Non-standard specimens shall be mounted in the chamber in a manner that will not inhibit flame propagation.

7.3.2 Materials that require a cure shall be prepared in the worst-case use thickness and cured according to the requester's instructions. The specimens shall be cut to 300 mm × 65 mm.

7.3.3 Coatings or any viscous material that cannot be mounted for testing without a substrate shall be applied to the end-use substrate material in the worst-case use thickness. Aluminium substrates approximately 0,5 mm thick may be used if the end-use substrate is unknown or inappropriate. Any requested cures shall be performed. The specimens shall measure 300 mm × 65 mm. Coatings, films or adhesive-backed tapes proposed for use on non-metallic surfaces shall be applied to the proposed non-metallic surface, in the worst-case use thickness.

7.3.4 Non-adhesive-backed hook-and-loop tapes shall be tested in the “as received” condition, unless otherwise noted by the requester. Adhesive-backed hook-and-loop tapes shall be applied to a 300 mm × 65 mm × 0,5 mm aluminium substrate. To ensure ignition of the tape backing, as opposed to the hooks or loops only, approximately 13 mm of the test specimen shall extend beyond the substrate.

7.3.5 Semi-solid materials shall be applied to a suitable non-combustible substrate such as glass-fibre cloth. Semi-solids shall be applied to the substrate as a uniform coat.

7.3.6 Liquid materials shall be tested using an appropriate standard test for determining the flash point of liquids.

7.3.7 Thin-film specimens shall be cut to 300 mm × 75 mm. Optionally, large thin films measuring 300 mm × 200 mm may be used, subject to the approval of the authority having jurisdiction, to reduce material shrinkage away from the flame.

8 Procedure

WARNING — Burning of materials may produce smoke and toxic gases, which can affect the health of operators. The test area shall be cleared of smoke and fumes by suitable means.

8.1 Before testing

Before testing, record all pertinent information (including oxygen concentration, specimen identification, and specimen pre-test mass and size). All specimens should be photographed.

The test system shall be visibly clean, and all measuring devices shall be in proper calibration.

The exposed centre section of standard-sized specimens shall be 50 mm wide. Specimens shall not be overly stretched or tightened, which would cause lines of horizontal stress. Mount thin films with 10 mm of slack in the width to allow for shrinkage.

Place the ignitor parallel to the lower edge of the specimen and centred along the plane of the front surface of the specimen, 6 mm ± 1 mm below the lower edge of the specimen. Care shall be exercised when testing materials on substrates to ensure that the ignitor is centred along the plane of the front surface of the specimen and not that of the substrate.

~~All tests should be videotaped.~~ All specimens shall be video recorded during testing.

8.2 Test

8.2.1 Before ignition

The test specimen shall be subjected to vacuum no less than 1 minute but no more than 3 minutes.

Prior to ignition, expose the specimen to the proper test atmosphere for a minimum of 3 min (exposure of the specimen to a vacuum shall be less than 3 min). At least ~~three~~ 5 replicate specimens shall be tested.

Measure, verify and record the percentage oxygen concentration and the total pressure.

Activate the chemical ignitor and the timing device used to measure the burn propagation time. Immediately upon ignition of the ignitor, turn off the power to the ignitor.

The ignitor shall be retracted from the test specimen once the ignitor extinguishes.

8.2.2 After ignition

Observe the vertical surfaces of the specimen and record any pertinent observations.

~~EXAMPLE Transfer of burning debris.~~

- Any flames emanating from the paper below shall be observed and noted.
- The paper shall be supported by a non-flammable, non-conducting screen material.
- Flame jets and sparks emanating from the specimen during combustion shall be observed and recorded.

8.3 After testing

After the test, record the final oxygen concentration, the burn length and the post-test mass. Post-test photographs should be taken, as required, to document any abnormal occurrences.

9 Accuracy

Measurements shall be made within the following tolerance limits:

a) absolute pressure: ± 1 %;

b) oxygen concentration: ± 0,5 %;

c) specimen dimensions: ± 5 %;

d) specimen mass: ± 1 %;

e) burn length: ± 10 mm.

10 Test report

10.1 Standard tests

The test report shall include details of the specimen identification, the specimen configuration, the test conditions and the observations from the test. Proper reporting of the test observations, such as the burn length, the transfer of burning debris, and other observations (especially of unusual behaviour) is critical. The test report shall be submitted to the authority having jurisdiction and/or the test requester.

10.2 Non-standard tests

When there is a deviation from standard test parameters, such as non-standard specimen preparation, specimen dimensions, specimen orientation, test stand or ignition source, the test shall be identified as non-standard. In addition, all information in 10.1 shall be reported.

Annex A
(informative)

Competency and accreditation of test facilities

A.1 Competency

Laboratories should be accredited to perform the flammability and/or combustion test methods contained within this part of ISO 14624. Accreditation is necessary because data from such testing is presented for aerospace flight material selection approval. Accreditation should be based on ISO/IEC 17025 and the specific requirements described in this part of ISO 14624.

The accreditation programme should include proficiency testing and should be consistent with ISO/IEC Guide 43-1.

A.2 Accreditation

Accreditation is the responsibility of the accreditation body recognized within its jurisdiction to administer laboratory accreditation. An acceptable laboratory accreditation body would be a signatory to the multi-lateral mutual recognition arrangement (MRA) of the International Laboratory Accreditation Cooperation (ILAC)[1)] or a signatory to an ILAC-equivalent regional/national MRA that requires accreditation bodies to conform to ISO/IEC Guide 58.

A.3 Guidelines

An accredited laboratory should conform to the following guidelines:

a) For required tests, the test facility should have performed the test method at least once during the last eighteen months and participated in comparisons of results with other accredited test facilities (round-robin testing).

b) All instrumentation used in the test should be in proper calibration and bear the appropriate documentation to validate traceability to appropriate national or international measurement standards.

c) The test facility should ensure that all testing is accomplished in accordance with approved test plans and procedures, and that the data records and test results are complete and accurate.

d) Complete test records should be prepared by the test facility for each material tested and the test facility should maintain a permanent record of test data for a minimum of fifteen years for historical purposes.

1) Full information is available at the web site http://www.ilac.org of ILAC - International Laboratory Accreditation Cooperation or through the ILAC Secretariat, c/o NATA, 7 Leeds Street, Rhodes NSW 2138, Australia. Tel.: +61 2 9736 8374, Fax: +61 9736 8373, e-mail: ilac@nata.asn.au

Annex B
(informative)

Preparation and qualification of chemical ignitors

Note - This annex provides one method of producing chemical igniters which produce a flame that meets the requirements for testing in atmospheres with oxygen concentrations between 15% and 50%. Any ignition source meeting the criteria outlined in this document may be utilized.

B.1 Safety requirements

All personnel associated with the manufacturing of these ignitors should be familiar with the safety requirements associated with the materials and equipment used.

B.2 Materials

B.2.1 Hexamethylenetetramine (HMT), 98 % pure reagent grade, in powder form, properly packaged and stored to prevent contamination by moisture.

B.2.2 Anhydrous sodium metasilicate, 98 % pure reagent grade, in granule form, properly packaged and stored to prevent contamination by moisture.

B.2.3 Gum arabic (acacia), in powder form.

B.2.4 Deionized water, for mixing with the dry ingredients to form the ignitor dough.

B.2.5 Certified breathing air, used in the certification of the ignitors (see ISO 14951-13).

B.3 Equipment

B.3.1 Hammer mill, for grinding the dry components of the ignitor mixture.

B.3.2 Glove box with a temperature/humidity meter, used when grinding some of the dry ingredients.
Note-Alternatively, igniters have been successfully manufactured in fume hoods, if the relative humidity was lower than 20%. See B3.5

B.3.3 Bags, for storing the ground dry ingredients.

B.3.4 40-mesh (40 µm) screen, for sieving the ground dry ingredients.

B.3.5 Fume hood, used when grinding some of the dry ingredients, and for mixing the ignitor dough. The air flow rate in the fume hood should be at least 30 m/s.

B.3.6 Respirator with organic canisters, used when grinding the HMT.

B.3.7 250 ml burette, for holding the deionized water and gradually adding it to the mixture.

B.3.8 Heavy-duty electric mixer, for mixing the ignitor dough.

B.3.9 Spatula, for scraping the sides of the mixing bowl during preparation of the ignitor dough.

B.3.10 Plastic trays, non-stick, measuring approximately 76 mm × 380 mm × 1,5 mm, to catch the extruded ignitor dough and hold it while it dries.

B.3.11 Conveyor belt, to move the plastic trays at a constant rate so that the string of ignitor dough is not stretched or allowed to become too thick.

B.3.12 Extruder, for extruding the ignitor dough on to the plastic trays.

B.3.13 Cutting tools, for cutting the ignitor dough string to the proper lengths.

B.3.14 Drying racks, for holding the plastic trays containing the ignitor dough string.

B.3.15 Desiccator with desiccant, to ensure that the proper humidity is maintained during drying and storage of the ignitors.

B.3.16 Balance, for weighing the dried ignitors.

B.3.17 Corrugated plastic holder, used when cutting overweight dried ignitors to a length that ensures the correct mass.

B.3.18 Power supply, capable of providing 15 A (RMS), used in the certification of the ignitors.

B.3.19 Bare 20 AWG nickel-chromium wire, with a nominal resistivity of 2,3 Ω·m, used in the certification of the ignitors.

B.3.20 Graduated ruler, for measuring the length of the ignitors and the ignitor flame height during certification.

B.3.21 Test chamber (or fume hood), used during certification of the ignitors.

B.3.22 Calibrated stopwatch, for determining the burn time during certification of the ignitors.

B.3.23 Soft-bristled brush, for cleaning the ignitor coil between certification of individual ignitors.

B.3.24 Plastic container (box), for storing the ignitors.

B.3.25 Corrugated foam wrap, for wrapping the stored ignitors.

B.4 Grinding the ignitor-mix ingredients

B.4.1 To ensure a homogeneous mixture, grind the raw materials using a hammer mill. Grinding is not necessary for the gum arabic.

B.4.2 Grind the sodium metasilicate in a glove box, as follows. Place the hammer mill, the material to be ground and any other necessary tools inside the glove box. Attach a bag to the output end of the hammer mill with tape to capture the ground material. In addition, place a 40-mesh screen inside the hammer mill. Seal the glove box and, before grinding the material, purge the glove box with dry air for approximately 4 h or until the humidity inside the glove box is below ~~10 %.~~ 20%

B.4.3 Grind the material. Detach the bag from the hammer mill, seal the bag, place it inside another bag and seal the second bag.

B.4.4 Clean the hammer mill between the grinding of different materials.

B.4.5 Grind the HMT in a fume hood. The air flow rate in the fume hood shall be at least 30 m/s, and a respirator with organic canisters shall be worn by the operator. Follow the same procedures as when grinding the sodium metasilicate described in B.4.2 to B.4.4.

B.4.6 After grinding, store each material separately, suitably identified.

B.5 Weighing and mixing the ignitor-mix ingredients

B.5.1 To make a 400 g mixture, the following amounts of each solid ingredient are necessary:

— (280,8 ± 0,2) g of HMT;

— (105,2 ± 0,2) g of anhydrous sodium metasilicate;

— (14,0 ± 0,2) g of gum arabic.

B.5.2 For other size batches, the mixture shall be comprised of 70,2 % ± 0,1 % HMT, 26,3 % ± 0,1 % sodium metasilicate and 3,5 % ± 0,1 % gum arabic.

B.5.3 Carry out the weighing and mixing on the day of extrusion (do not mix the dry ingredients prior to the day of extrusion).

B.6 Adding water

B.6.1 Pour 200 ml of deionized water at room temperature into a 250 ml burette.

B.6.2 Open the tap of the burette and allow approximately 10 ml of deionized water to flow into the mixing bowl of a heavy-duty electric mixer.

B.6.3 Place the dry ignitor mix in the mixing bowl. Ensure the ignitor mix is evenly distributed in the bowl.

B.6.4 Operating the electric mixer at low speed, slowly add deionized water to the mixture. Initially, the mixture will be very wet. As the sodium metasilicate absorbs the water, the mix will start to thicken, and will eventually achieve a dough-like consistency. This could take 20 min to 30 min, depending on the environmental conditions. During mixing, scrape the sides of the mixing bowl with a spatula.

B.6.5 As the proper dough-like consistency is achieved, the mix will start to pull away from the sides of the bowl. When this occurs, stop adding water. Too much water will cause the mixture to be too wet to extrude. Generally, 190 ml to 200 ml of deionized water will be added from the burette to the mixture.

B.7 Extruding the ignitors

B.7.1 Extruding the ignitors is a three-person operation. One person places the plastic trays on the conveyor belt. Another person controls the process by adjusting the conveyor belt speed and the extruder controller speed, and cuts the extruded ignitor dough between trays. The third person removes the trays from the conveyor belt and places them in drying racks.

B.7.2 Turn on the conveyor belt and make any necessary adjustments to belt tension to prevent any belt hesitations. In addition, for a 400 g mixture, make sure that there are approximately 75 plastic trays next to the beginning of the conveyor belt. More will be needed for a larger batch. Turn the conveyor belt off.

B.7.3 Assemble the extruder and fill with ignitor dough.

B.7.4 When extrusion starts, turn the conveyor belt on and be ready to place the plastic trays on the conveyor belt as the ignitor dough exits the extruder. Adjust the conveyor belt and extruder speed as required during this operation to ensure that the extruded ignitor dough comes out straight and unstretched. Cut the dough between trays, so that the trays may be placed individually in the drying racks.

B.7.5 After all the dough has been extruded onto the trays, and the trays removed to the drying racks, clean all the equipment.

B.8 Curing, cutting and weighing the ignitors

B.8.1 After all the ignitor dough has been extruded onto the plastic trays, place the ignitors in a well-ventilated area (relative humidity < 20 %) to dry. After approximately ~~24 h to 48 h~~ 30 days the ignitors should be dry enough to cut.

B.8.2 Cut all the ignitor strings on the plastic trays to a length of 28 mm ± 3,2 mm. Continue to dry the cut ignitors under the conditions described in B.8.1 for another ~~24 h to 48 h until they are dry to the touch.~~ 6 months.

B.8.3 Transfer the ignitors from the plastic trays to a desiccator (relative humidity < 15 %). Place them directly on the desiccant bed.

B.8.4 Continue to dry the ignitors inside the desiccator. After approximately seven days, select ten ignitors and weigh them. The mass specification for the ignitors is 190 mg to 240 mg. If the mass of eight out of the ten ignitors is within the specified range, the final dried state has been reached, and the ignitors are ready for certification. If more than two ignitors weigh over 240 mg, continue to dry the ignitors.

2 to 3 months

B.8.5 If more drying time is required, as described in B.8.4 above, wait approximately ~~24 h to 48 h,~~ then select ten additional ignitors. If eight out of the ten meet the mass specification, the ignitors are ready for certification. Due to varying conditions in desiccators, this process may take as long as ~~two weeks, or more~~.

9 to 12 months.

B.9 Certifying the ignitors

B.9.1 Weigh all the ignitors in the desiccator. If an ignitor weighs less than 190 mg, it is underweight, and shall be discarded. If an ignitor weighs more than 240 mg, it may be cut down to 25 mm long to meet the mass specification. If the proper mass is not achieved within the length specification, the ignitor shall be discarded. Cutting and weighing of the ignitors shall be done in a dry environment (relative humidity < 20 %), since the ignitors will absorb moisture when exposed to excess humidity. In addition, the ignitors shall remain circular, and not flatten out while curing, in order to fit inside the ignition coil. To ensure this, ignitors shall be placed in a rigid plastic corrugated holder while being cut.

B.9.2 To certify a 400 g mixture batch, randomly select a sample of 20 ignitors. If a larger mixture batch is made, the certification sample shall be increased accordingly. The 20 ignitors selected shall be tested for the peak flame temperature, burn time and peak flame height. Each ignitor tested shall develop a flame temperature of 1 100 °C ± 90 °C. The ignitor flame shall be sustained for 25 s ± 5 s with a peak flame height of 65 mm ± 6,5 mm.

In additions, test 5 ignitors for heat of combustion. The gross heat of combustion of ignitors shall be 1050 =/- 70 cal.

B.9.3 Ignitors shall be tested in certified breathing air at 100 kPa. The temperature shall be measured by a type S thermocouple constructed with a 0,81 mm diameter wire. The thermocouple wire shall be centred geometrically 25 mm above the top of the ignitor. To initiate the ignitor, a power supply capable of providing 15 A (RMS) shall be connected to a bare 20 AWG nickel-chromium wire. The wire shall have a nominal resistivity of 2,3 Ω·m and shall have sufficient length to wrap three equally spaced turns around the ignitor. The nickel-chromium wire coil shall be replaced before certifying each batch of ignitors. In addition, the length of the leads to the nickel-chromium wire coil shall not exceed 32 mm to ensure proper ignition of the ignitor. A graduated ruler shall be placed in the test chamber to measure the flame height.

B.9.4 Before starting the certification, ensure that the thermocouple wires are not touching each other, and that the thermocouple is in proper calibration.

B.9.5 To certify a batch of ignitors, perform the following steps for each of the 20 randomly selected ignitors.

a) Place the ignitor in the nickel-chromium wire coil.

b) Pressurize the test chamber to 100 kPa with certified breathing air.

c) Turn on the power to the ignitor. When ignition is accomplished, turn the power off.

d) Record the peak flame temperature (from the thermocouple), the burn time and the flame height. The time from the moment of ignition to the moment of flame extinction (burn time) shall be obtained using a calibrated stopwatch. The flame height shall be determined by measuring the maximum height of the flame to the apex.

e) Allow the test chamber to stabilize. Before loading the next ignitor, clean the wire coil by removing any ash residue with a soft-bristled brush.

f) The batch of ignitors is acceptable for use when no more than one ignitor out of the 20 tested fails the specified criteria (see B.9.2). Once the batch of ignitors has been tested and certified, calculate the average peak flame temperature and average burn time, along with their standard deviations.

B.10 Waste disposal

Dispose of any waste generated from manufacturing, cutting or weighing ignitors, including an entire batch that fails, in accordance with applicable hazardous-waste/environmental regulations.

B.11 Packaging and storing ignitors

B.11.1 Package the ignitors in a plastic storage container between layers of 3-mm-thick corrugated foam wrap. Place the ignitors in the grooves of the corrugated wrap. The order of placement in the storage container shall be:

1) corrugated wrap with grooved side up;

2) layer of ignitors, in grooves of corrugated wrap;

3) corrugated wrap with grooved side down.

Repeat steps 1) to 3) until the container is full. This order of placement will put two layers of corrugated wrap between each layer of ignitors, and minimize movement when the box is moved or stored. To absorb any excess moisture which might affect the performance of the ignitors, place packets of desiccant on top of the ignitors, inside the container.

B.11.2 To prevent the ignitors from absorbing moisture during an extended storage period, place the packaged ignitors in a desiccator with a colour-changing desiccant or another type of humidity indicator. The ignitors may be stored for an indefinite period of time, provided the desiccant is changed regularly and/or the humidity in the desiccator is kept below 18 %.

Bibliography

[1] ISO 14951-13:1999, *Space systems — Fluid characteristics — Part 13: Breathing air*

[2] ISO/IEC 17025:1999, *General requirements for the competence of testing and calibration laboratories*

[3] ISO/IEC Guide 43-1:1997, *Proficiency testing by interlaboratory comparisons — Part 1: Development and operation of proficiency testing schemes*

[4] ISO/IEC Guide 58:1993, *Calibration and testing laboratory accreditation systems — General requirements for operation and recognition*